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RADIOACTIVITY AND LIFE *

By C. Stuart Gager

1. The Supposed Radioactivity of Plants and of Wood

Soon after the discoveries of "contact" electricity and "animal" electricity by Volta and Galvani, plant physiologists began to look for electric currents in plants, and to find therein the explanation of "vital" activity. In a similar manner the announcement of the discovery of radioactivity has been followed by numerous supposed observations of a natural or acquired radioactivity of plants and plant tissues.

Professor A. B. Greene[2] was among the first to report that microörganisms, especially species of *Staphylococcus*, after an exposure of from 24–120 hours to radium rays at a distance of 0.5 mm., themselves exhibit phenomena of radioactivity. He considers it uncertain as to whether living organisms can acquire this property, but states that those killed by the action of radium rays can do so. In his experiments the radium salt was enclosed in a vulcanite and brass capsule, and the radioactivity acquired by the organisms lasted for three minutes after the termination of the exposure, and enabled them to photograph themselves on a sensitive plate. Their spores were found to be best for this purpose.

Lambert[3] stated in 1904 that ferments that digest albuminous matter emit Blondlot rays, and that the emission of these rays is the cause of the action of the soluble ferments.

The experimental demonstration of the emission of the so-

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called N rays by plants of the garden cress was reported by Meyer.[4] Their emission, he said, varies with the activity of the protoplasm, and is diminished when the plants are exposed to the vapor of chloroform, and is modified by mere compression of the tissues.

In 1904 Russel[5] described before the Royal Society the rather startling discovery of the action of wood on a photographic plate in the dark. This property, he said, belongs probably to all woods. Conifers are especially active, and the spring wood most of all, but the dark autumn wood produced no such effect. Oak, beech, acacia (*Robinia*), Spanish chestnut, and sycamore possess this property, but ash, elm, the horse-chestnut, and the plane tree only to a slight degree. Most resins manifest it, but not so the true gums, such as gum senegal and gum tragacanth. Exposure to sunlight, especially to the blue rays of the spectrum, increases the activity. Cork, printer's ink, leather, pure India rubber, fur, feathers, and turpentine are reported to have their activity increased in the same way. Since bodies such as slate, porcelain, flour, and sugar, in which there is no resinous or allied body, do not react in this way, nor affect the plate at all, the activity of the various kinds of wood is attributed to the resinous substances in them.

Tommasina's[8, 9] papers were also published in 1904. He reported that all freshly gathered plants, fruits, flowers, and leaves possess a radioactivity which is stronger in the young and in individuals in action than in those at rest, being apparently proportional to the vital energy. For this phenomenon he proposed the term *bio-radioactivity*. Buds of lilac, and leaves of *Thuja* and of laurel were found by him to be bio-radioactive.

In the following year Tarchanoff and Moldenhauer[7] published their preliminary note on the induced and natural radioactivity of plants, and on its probable rôle in their growth. When seeds of various grains and of the pea were exposed to the radium emanation, the seedlings growing from such seeds showed induced radioactivity in their roots, but the stem and small leaves remained inactive. Also when a mature plant was exposed to the emanation the roots became strongly radioactive, the stem somewhat less so, the leaves only slightly, and the flowers not at all.

This distribution of the radioactivity in the plant body is constant, and the authors consider that there is in the plant a special substance, sensible to the emanation, and capable of becoming radioactive under its influence. This substance occurs in the roots, but gradually diminishes up the stem. It is found also in seeds. According to this same paper plants possess a natural radioactivity, which is distributed throughout the plant similarly to the induced radioactivity. This natural radioactivity is strong enough to affect a photographic plate, and plays an important rôle in the development of the plant.

In a second paper Russel[6] gives a list of 33 native and 22 foreign woods that are active, and says that the activity of resins and gums is increased by exposure, not only to sunlight, but to the arc-light as well. Photographic plates often contain a negative of the plate-holder. That this is not a case of radioactivity appears to be proved, says the author, for a glass or a mica screen of one thousandth of an inch in thickness entirely protects the plate from being acted on.

Finally Paul Becquerel[1] undertook a careful study of "plant radioactivity." He tested pea seeds, moss (*Hypnum*), and branches of boxwood for radioactivity, but found not a trace of it manifest when the electroscope was carefully guarded from water-vapor. This explains the condition found necessary by Tommasina, that the parts of plants must be freshly picked in order to manifest bio-radioactivity. According to Becquerel, the discharge of the electroscope in Tommasina's experiments was due to the water in the plants.

From all the investigations noted above, the general conclusion seems to be warranted that radioactivity is not a property of protoplasm nor of living tissues. A clear understanding of the nature of radioactivity would lead, *a priori*, to the same inference.

2. The Professed Artificial Creation of Life

Radioactivity and vital activity are in two respects very roughly, but only very superficially analogous. Both radioactive bodies and living organisms are undergoing a destructive process; atomic disintegration in the one, molecular transforma-

tion in the other; both, with exceptions, maintain themselves constantly at a higher temperature than their surroundings. These analogies have in two or three instances proven dangerously attractive.

A consideration of radioactivity led Dubois,[18] in 1904, to the view that the distinction between "matter of life" and "living matter" is superficial. He proposed the term *bioproteon*, meaning the particular state of the "proteon" in living beings, and suggested the desirability of determining the radioactivity proper of the bioproteon. In a subsequent paper[21] he says: "The unique principle of everything, of both force and matter, I have called 'proteon,' and when it pertains to a living being, 'bioproteon'." Proteon and bioproteon are only two different states of the same thing. When the bioproteon is dead it has only ceased to be radioactive and becomes simply proteon. He claimed also to have discovered the emission, from the lamellibranch mollusc, *Phaladea dactyle*, of rays that could penetrate paper and opaque substances and darken a sensitive plate.

Early in the year 1905 appeared his paper[19] on "*La création de l'être vivant et les lois naturelles*" in which he announced the formation of living organisms in bouillon gelatine by placing on it crystals of the bromide of both barium and radium. Later in the same year[20] he claimed to have secured a kind of spontaneous generation by radium. By the contact of certain crystalloids with organic colloids, there are obtained, he says, granulations, or vacuolides, possessing the optical and and morphological characters of simple life, more rudimentary than bioproteon, or living matter. These bodies arise, grow, divide, grow old, and die, returning to the crystalline state like all living things, and Dubois applied to them the generic term *eobe* (dawn of life). Eobes are held to form the transition between the organic and the inorganic world. In his essay[21] on "*La radioactivité et la vie*," he elaborates the hypothesis that the energy irradiated by living beings has two distinct origins — one from the environment, and one ancestral or hereditary. By their "ancestral energy" living beings are similar to radioactive bodies. They both give off heat rays, light, chemical rays, electricity, and possess molecular motion, and atomic and other movements.

Leduc's[26, 27] profession to have created life was controverted by Bonnier,[10] Charrin and Goupil,[17] and by Kunstler,[25] in 1907.

The most extravagant claims made in this direction are those of Burke,[11-16] whose observations on the spontaneous action of radioactive bodies on gelatine media form the basis of a voluminous work entitled "The Origin of Life." While these experiments have little of the scientific importance they have been held to possess in the popular mind, it is desirable to state, in Burke's own words, what he did, and his own interpretation of the results.

"An extract of meat of 1 lb. of beef to 1 liter of water, together with 1 per cent. of Witter peptone, 1 per cent. of sodium chloride, and 10 per cent. of gold labelled gelatine was slowly heated in the usual way, sterilized, and then cooled. The gelatine culture medium thus prepared, and commonly known as bouillon, is acted upon by radium salts and some other slightly radioactive bodies in a most remarkable manner."[12]

When the mixture above described was placed in a test-tube and sterilized, and the surface sprinkled with 2.5 grains of radium bromide (activity not given), after 24 hours (three to four days when radium chloride was used), "a peculiar culture-like growth appeared on the surface, and gradually made its way downwards, until after a fortnight, in some cases, it had grown nearly a centimeter beneath the surface." From this growth Burke was not able to make sub-cultures. He considers them not bacteria, and not contaminations, but "highly organized bodies." They have "nuclei", subdivide when a certain size is reached, and "the larger ones appear to have sprung from the smaller ones, and they have all probably arisen in some way from the invisible particles of radium." He regards them as colloidal, rather than crystalline, "of the nature of 'dynamical aggregates' rather than of 'static aggregates'," and coins for them a new name, *radiobes*. This forms the experimental basis for a volume of 351 pages.

With reference to these discoveries, Dubois[22] claims priority over Burke, and rejects his term radiobe in favor of eobe, because these bodies may be obtained with non-radioactive substances.

A few months after Burke's announcement Rudge[28, 29] showed

that the alleged growths were "nothing more than finely divided precipitates of insoluble barium salts." He was unable in a preparation similar to the one described by Burke, to observe anything like cell-division, and believes that an occasional grouping of the particles in pairs must be purely fortuitous. The appearance of growth of the radiobes is explained as due to diffusion of the precipitate through the gelatine from a point of concentration where the radium salt was in contact with the gelatine. Salts of barium, lead, and strontium produced effects exactly similar to those caused by radium preparations.

Again repeating Burke's experiments, Rudge[30] was unable to secure the radiobes when agar-agar was substituted for gelatine and distilled water was used. If tap-water was employed a slight growth resulted, while the addition of a soluble sulfate resulted in a very dense growth. An examination of 30–40 samples of gelatine showed that they all contained enough H_2SO_4 to give a distinct, sometimes a dense, precipitate with barium chloride in the presence of HNO_3. This precipitate was found, on analysis, to be $BaSO_4$. Gelatine was then prepared free from sulfates and gave no growth. Negative results were obtained with salts of uranium, thorium, pitchblende, and metallic uranium, thus clearly indicating that there is not the slightest connection between the formation of the rabiobes and radioactivity.

A sample of gelatine from which H_2SO_4 had been removed was sealed with a radium salt from June until September. At the end of that time no growth appeared, but when a soluble sulfate was added to a portion of this gelatine the growth began at once.

"The cellular form of these precipitates," said Rudge, "is probably due to the circumstance that the gelatine is liquefied by the action of the salt, and each particle of precipitate is formed about a core of gelatine, so that the layer of barium sulfate forms a kind of sac or cell which is surrounded by the solutions of the salt in the liquefied gelatine. This 'cell' may be permeable to the liquefied gelatine containing a salt in solution, which, passing through the cell-wall, causes an expansion to take place, the limit of growth being controlled by some surface tension effect."

No trace of a nucleus or of mitosis was observed under the

very highest magnification, and " cells " under a cover-glass sealed down with cement were observed to suffer no alteration during four months.

Reference to the extreme claims noted in some of the literature above cited may be fittingly concluded by the following quotation from Lord Kelvin :[24]

" But let not youthful minds be dazzled by the imaginings of the daily newspapers that because Berthelot and others have . . . made foodstuffs they can make living things, or that there is any prospect of a process being found in any laboratory for making a living thing, whether the minutest germ of bacteriology or anything smaller or greater."

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NOTES ON FERNS SEEN DURING THE SUMMER OF 1908

By Ralph Curtiss Benedict

Dryopteris Goldiana × *marginalis* Dowell.

A second locality for this interesting hybrid is to be recorded, the Green Lake region near Jamesville, N. Y., where so many ferns are found. The original collection of *D. Goldiana* × *intermedia* Dowell was made in the same region, and the trip in question had in view the finding of this fern, but it was not secured again although the parent species were seen in abundance and